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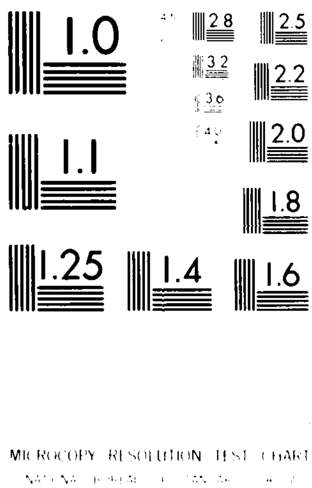
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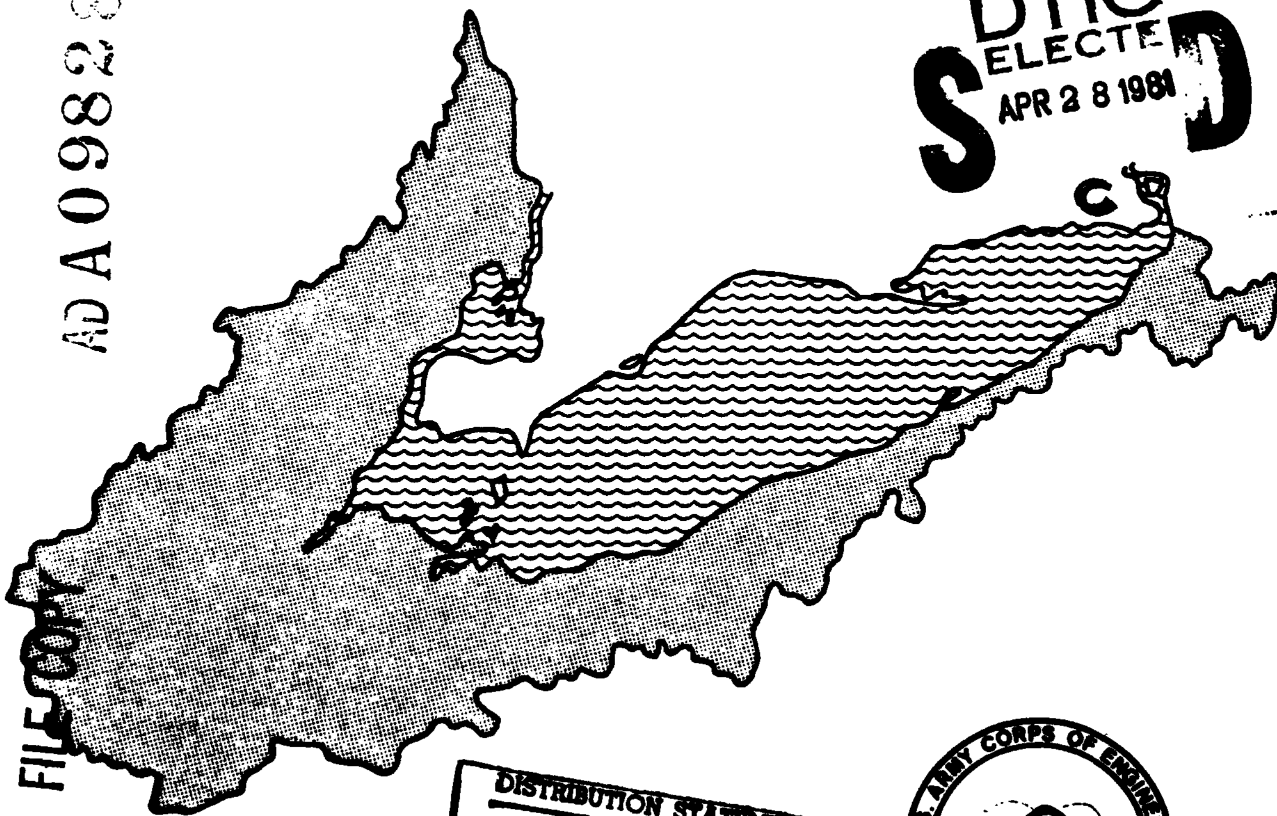
FARMER EXPERIENCES WITH ALTERNATIVE TILLAGE PRACTICES IN THE WESTERN LAKE ERIE BASIN



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FARMER EXPERIENCES WITH

ALTERNATIVE TILLAGE PRACTICES

IN THE WESTERN LAKE ERIE BASIN

by

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Prepared for:

Corps of Engineers
Buffalo District

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ABSTRACT

It is hypothesized that using reduced tillage systems on selected soils slightly increases producers' net incomes and sharply reduces soil loss and substantially improves water quality. To test the hypothesis that reduced tillage systems slightly increase producers' net incomes, 156 farm observations of various tillage systems were selected. The observations were dispersed across 10 counties in the western Lake Erie Basin. Comparisons were made of yields and net incomes between various tillage systems.

Results support the economic feasibility of reduced tillage systems. Both yields and net incomes were slightly larger for reduced tillage systems than for conventional tillage. However, the improvement in net incomes and yields was not statistically significant for most reduced tillage systems.

Background

The Lake Erie Wastewater Management Study was mandated by Congress in Sections 108 (d) and (e) of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). The study was organized in three phases. In Phase I, conducted during 1974, 1975 and the first half of 1976, sources of pollutants were identified. A large scale program of tributary sampling was carried out across the Lake Erie Basin in conjunction with assembling current information on various sources of pollution in the lake. An important conclusion of Phase I was that about half of the pollutant load to the lake came from land runoff.

Phase II, conducted in 1976, 1977 and part of 1978, concentrated on analyzing the impacts of alternative land management practices (a) on water quality, and (b) on net farm income. One conclusion was that adoption of reduced tillage practices appeared to be an economically feasible method of reducing erosion and improving water quality. Using reduced tillage practices on selected soils was estimated to increase net farm income. Other water pollution control practices, such as rotating crops, changing land use, and installing in-stream treatment, presented huge costs to farmers and society (U.S. Army Corps of Engineers). Obviously, reduced tillage is a preferred method of controlling water pollution if these estimates are correct.

Phase III is scheduled for completion in September of 1982. It calls for the implementation of a demonstration watershed management program using "best management practices." In addition, five watersheds are to be selected for development of technical assistance programs in

preparation for demonstration programs using recommended "best management practices." Best management practices (BMPs) involve the most practical and effective measures or combination of measures which when applied to the management unit will prevent or reduce the generation of pollutants to a level compatible with water quality goals. Of course reduced tillage practices are the most promising BMPs in the Lake Erie Basin.

Objectives

The general purpose of this study is to examine farm experiences in the Lake Erie Basin to discover if current users of reduced tillage technologies are receiving economic benefits from these practices. This information is needed to gauge the responses of farmers in adopting reduced tillage systems. It may also help educators decide the proper emphasis to be placed on the various "selling" points of this relatively new technology. Results will be very important in helping to decide whether the desired water quality standards can be reached through voluntary actions by farmers. Specific objectives are the following:

1. To determine annual net returns associated with conventional tillage and reduced tillage practices for corn production on selected soils.

2. To determine annual yields under conventional tillage and reduced tillage practices for corn production on selected soils.

3. To compare farmers' yields and net returns under alternative tillage systems on selected soils with those published in previous research.

Research Comparing Various Tillage Technologies

If alternative tillage systems are to be promoted as methods of reducing soil loss and thus improving water quality, their effectiveness must first be proven. Harrold, in 1960, reported on a three-year soil loss test of minimum tillage (plow-plant) as compared to conventional tillage in Coshocton, Ohio. Results showed that the three-year total loss from a cornfield to be 8 tons per acre for conventional tillage versus a 1.23 ton per acre loss from the minimum tilled field (Harrold). The amount of mulch was a factor in protecting it from raindrop splash erosion.

Meyer et al. stated that a mulch of only 1/4 ton per acre reduced soil erosion to about 30 percent of unmulched soil (Meyer). With the high residue content on no till fields, the results are even more clear. Harrold and Edwards documented soil loss under a severe rainstorm in which more than 5 inches of rain fell in 7 hours (Harrold et al.). The land slopes of the two conventionally tilled fields was 6 percent and the no till field was 21 percent. The soils for both were well-drained. The sediment yield for conventional Field I with poor management practices had a measured sediment yield of 45,300 pounds per acre while conventional Field II with good management practices yielded 6,430 pounds of sediment per acre. The no till field yielded only 63 pounds per acre. Such results are impressive and suggest great potential in reducing soil loss.

Reduced tillage technologies show great promise in reducing the problem of wind erosion which affects the sandy beach ridges of northwestern Ohio. In a trial by Schmidt and Triplett, 130 tons per acre was

lost from a plowed-planted cornfield as compared to only 2 tons per acre from a no tillage planted cornfield during one severe windstorm. Schmidt and Kroetz reported relative soil losses for fall plowed, spring plowed and no tilled fields as 2,605, 848 and 119 grams respectively. They concluded that no tillage consistently reduced wind erosion on sandy textured soils, but added that excessive residue on the surface may reduce soil temperatures enough to reduce yields on poorly-drained, sandy loam soils.

Other benefits have been attributed to reduced tillage technologies that may increase its attractiveness to farmers in the Lake Erie Basin. These benefits may have monetary advantages for adopters of reduced tillage. Studies in Kentucky have shown that early planting of corn with no tillage is not as critical as early planting under conventional methods (Blevens). Planting dates can therefore be extended without the reduced yields normally occuring in conventional tillage as the planting is delayed.

Crop success depends on having adequate moisture throughout the growing season. Water stress, even when not visible as plant wilt, can affect plant vigor, size and yield. Moisture levels are aided by increasing water infiltration rates and reducing evaporation. Moisture levels in minimum tillage and no tillage fields are higher than in comparative conventionally tilled fields.

Soil compaction by heavy farm machinery operating over wet soil was avoided by no tillage and some reduced tillage technologies. Since the machinery operations of no tillage culture are only planting, spraying and harvesting, the opportunity for plow pans to develop reduces.

Good soil structure is important to satisfactory plant growth, in providing a storage space for water in soil pores created by stable soil aggregation and in preventing surface puddling or crusting of soil (Bealle and Langdal). There is evidence that reduced tillage can improve soil structure by influencing the organic contents of soils. In South Carolina, the organic matter of a minimum tilled field increased to 1.59 percent after 4 years, while the organic matter of the same soil in a conventionally tilled field rose to only 1.28 percent. Soil organic matter content and renewal are directly related to soil moisture retention, evaporation, moisture availability, availability of plant food, erosion, soil compaction and the stability of the soil's structure.

Different soils vary in their response to different tillage systems. Thus, the benefits described above depend on the way a particular soil type responds to reduced tillage systems. No tillage, for example, is a radical change from traditional farming methods. The difference in response of various factors, including yield, differ enough to be a critical element when selecting the proper tillage system. For some soils, under particular climate and cultural contiions, no till corn may offer significantly higher yields than conventionally grown corn. The opposite may be true for other soils under different growing conditions.

Perhaps the most important factor in determining the suitability of a particular soil to minimum tillage and no tillage is the degree of soil drainage. Poor drainage negatively influences plant growth by its effects on aeration, compaction and soil temperature. Tile or surface

drainage may increase the suitability for reduced tillage in some soils as will delayed planting until temperatures are high enough for rapid seeding. Continuous no till corn growth on poorly drained soils has resulted in a yield reduction of 10-20 percent when compared to continuous corn planted in fall-plowed soil (Triplett et al.). Reasons are not known for this yield reduction at the present time.

On well-drained, low-organic-matter soils with a tendency to crust, mulch cover is responsible for the benefits derived from reduced tillage. Without the mulch as a protective cover on the soil surface, raindrops would seal the surface and runoff would occur. The mulch also serves to reduce evaporation and maintain a more constant moisture level and temperature.

Tillage Soil Management Groups

For the purpose of the Lake Erie Wastewater Management Study, the soils of the Lake Erie Basin were identified and the number of hectares of each was listed (Cahill). Using soil series yield data and other unpublished sources, yield data was obtained for each soil series. Then each soil series was placed into one of five soil management groups based on soil properties and their influences on factors relating to response to the no tillage system. These soil management groups were those identified by Triplett et al.. They are as follows:

Tillage Group 1 - Soils included in this group should have yield response to no tillage equal to or greater than conventional tillage. Soils are moderately well, well, and excessively well-drained. They have silt loam, loam, sandy loam, or loamy fine sand surfaee texture. They are low in organic matter.

Tillage Group 2 - These soils should have yield responses to no tillage nearly equal to conventional tillage if soil drainage has been improved. These soils are somewhat poorly drained in their natural state. They have a silt loam, loam, sandy loam, or loamy fine sand surface texture. They are low in organic matter.

Tillage Group 3 - These soils yield less with no tillage than conventional tillage. They are somewhat poorly to very poorly-drained. Tile does not provide adequate drainage. Surface texture is loam, silt loam, or silty clay loam. Most of these soils are low in organic matter.

Tillage Group 4 - Soils in this group may yield less with no tillage than conventional tillage. They are very poorly drained. They have surface textures of silty clay loam, clay loam, silty clay, or clay. They contain relatively high amounts of organic matter in the surface.

Tillage Group 5 - These are organic soils, alluvial soils, and certain fine-textured soils. These soils do not respond well to no tillage corn.

As seen from this classification, soils in soil management groups 1 and 2 are thought to respond well to reduced tillage technology.

Simulation Model for the Lake Erie Basin

Forster, in a report prepared for Lake Erie Wastewater Management Study, Buffalo, developed a model to assess the economic aspects of changing tillage practices in the Lake Erie Basin (Forster, Aug. 1978). In this model, each soil management group was assigned yield indices for reduced tillage systems for corn. This data, for Ohio, was obtained from a number of experimental trials conducted by the Ohio Agricultural Research and Development Center. Data from other states was adapted or estimated by experts in those states. These indices were based on expectations of probable yields using yields expected on conventionally tilled soils as the base (Table 1).

Table 1: Yield Indices for Various Tillage Systems, by Soil Management Group; Ohio, Indiana and Michigan.

Soil Management Group	Ohio, Indiana		Michigan a/		Conventional Tillage
	Minimum	No Till	Minimum	No Till	
1	100	102	100	100	100
2	105	104	100	100	100
3	90	85	90	85	100
4	96	87	96	87	100
5	NA	NA	NA	NA	100

Sources: D.L. Forster, N. Rask, S.W. Bone, and B.W. Schurle, "Reduced Tillage Systems for Conservation and Profitability," Dept. of Ag. Econ. and Rural Soc., ESS 532, The Ohio State University, 1976.

S.W. Bone, D.M. VanDoren, and G.B. Triplett, Jr., "Tillage Research in Ohio," Bulletin 620, Cooperative Extension Service, The Ohio State University.

a/ Adaptation of Ohio and Indiana Yield Index. Groups 1 and 2 were adjusted to allow for no yield advantage from reduced tillage. This assumption is made since published research could not be found to support higher yields in Michigan.

In his computerized simulation model, Forster describes seven different management scenarios depicting returns under the adoption of minimum tillage or no tillage on selected management groups.

Output from the model included (a) net return per acre by crop, by tillage system, by county, and by soil series; (b) acres in each county by soil management group; (c) net return for each county by management scenario, and (d) net return for the Lake Erie Basin by management scenario. The following chart illustrates the scenarios as used by Forster:

Management Scenario	Soil Management Groups Using: Conventional Tillage	Minimum Tillage	No Tillage
A	1 2 3 4 and 5		
B	2 3 4 and 5	1	
C	1 3 4 and 5	2	
D	1 2 4 and 5	3	
E	1 2 3 and 5	4	
F	2 3 4 and 5		1
G	1 3 4 and 5		2

In Scenario A, conventional tillage is used on all soils. In B, minimum tillage is used just on soils in soil management group 1, and all other soils are conventionally tilled. In C, minimum tillage is used exclusively on soils in soil management group 2, etc.

Under Scenario A, with all soil groups using conventional tillage, basin net farm income totals $338.2 million. With the implementation of minimum and no tillage technologies on soil management groups, basin net farm income changes as follows:

Scenario	Change in Basin Net Income (%)
Minimum Tillage on	
-Group 1 soils	+1.3
-Group 2 soils	+4.9
-Group 3 soils	-3.7
-Group 4 soils	-1.2
No Tillage on	
-Group 1 soils	+2.2
-Group 2 soils	+5.9

As seen above, basin net farm income actually improves with the adoption of minimum and no tillage with soils in management groups 1 and 2. Net income declines when minimum tillage is implemented on soil management groups 3 and 4.

Forster concludes that for the Lake Erie Basin, reduced tillage farming of well-drained soils with concurrent conventional farming of poorly-drained soils may result in a one to six percent increase in the Basin net income compared to conventional tillage farming of the entire watershed.

These results may be significant to the long-term efforts to institute best management practices throughout the Lake Erie Basin. The effort to reduce soil erosion and improve the water quality of Lake Erie is dependent on convincing farm operators that they too can increase their net income by adopting reduced tillage technologies.

Adoption of Reduced Tillage Practices

For any new innovation, the experiences of the adopters during the early phases of diffusion will have a great influence on the ultimate

course of diffusion. Reduced tillage is still relatively new to many farmers in the Lake Erie Basin. Therefore, to those who advocate reduced tillage methods, the experiences of early adopters are quite important. Until very recently very little was known about the diffusion of reduced tillage farming.

In a sociological study of no tillage farmers in Kentucky, it was discovered that few farmers who utilize no tillage have abandoned conventional till methods of production (Choi). Although research challenges the basic reasons for extensive tillage (Phillips), the overwhelming majority of farmers considered plowing essential for good farm management. Therefore, despite research findings indicating that tillage operations are not essential in crop production and can be replaced by the proper use of chemicals, most are slow in abandoning customary practices.

To the advocates of best management practices, their most important attributes are soil conservation and energy savings. Many experts agree that large-scale applications of reduced tillage practices is particularly desirable as a means of protecting soil resources so as to ensure permanent agriculture. Choi, in Kentucky found that farmers do not accord the same status to the soil production potential. More farmers (37%) considered labor savings to be the most important attribute of no tillage. Only 19 percent considered erosion control the most important contribution of reduced tillage.

A similar type survey conducted in the Lake Erie Basin, concluded that farmers considered reduced fuel costs the most important attribute of reduced tillage systems (Forster, Nov. 1979).

In the Lake Erie Basin, best management practices (or BMPs) have more often been linked to reducing soil erosion and improving water quality. In a study conducted in northwestern Ohio, 80 percent of the respondents indicated that erosion contributed to pollution (Shindler, et al.). A Basin-wide survey, conducted three years earlier, indicated a much lower percentage (44.9%) listing erosion as a source of water pollution. So, it seems that the increasing emphasis by educators is indeed having the effect of making farmers aware of the water quality problem (Great Lakes Basin Commission).

Research has shown that reduced tillage practices may be very effective on well-drained soils. Reduced tillage will reduce erosion and maintain or increase yields on sloping soil (Meyer, et al.). It has also shown that reduced tillage on the poorly-drained, level, fine-textured clay soils, found in northwestern Ohio, may reduce yields and yet have little or no effect on improving water quality.

Farmers were asked if they would be willing to take a yield reduction, since reduced tillage usually reduces the costs of production. In response, 42 percent of the farmers were not willing to take a yield reduction.

These results indicate that farmers believe that there are more risks involved with reduced tillage technology, and they were reluctant to take a higher risk and potentially-reduced yields (Shindler, et al.).

It is apparent that, if improved water quality is to be achieved through voluntary adoption of reduced tillage practices, the best strategy would be to encourage reduced tillage on only those soils which respond favorably to the new technologies. To do otherwise would delay

the diffusion of reduced tillage technologies throughout the Basin by creating counter-productive attitudes that discourage greater experimentation and ultimately adoption.

Data Collection

Economic data were collected by means of telephone interviews with respondents during summer 1980. A total of 156 tillage observations provided data encompassing farmers' operations during crop year 1979. A total of 89 different farmers participated in the study with individual farmers contributing as many as 4 tillage observations. This number of observations from a single source was determined by a farmers willingness to experiment with various tillage systems.

For the purpose of this analysis, the classification of each observation as to tillage system is based on what particular tillage operation was performed. These groups are:

1. Conventional - This group consists of those observations where where the field was either fall or spring plowed with secondary tillage performed as the farmer felt necessary.

2. Chisel Plow - This group consists of those observations where the field was either fall or spring chisel plowed with secondary tillage performed as the farmer felt necessary.

3. Minimum Till - This group of observations consists of those observations where only secondary tillage was performed prior to planting.

4. No Till - This largest group of observations consists of those where there was neither primary nor secondary tillage and planting was accomplished by means of a no till planter.

A breakdown of the 156 total observations into the four major tillage systems used in the study gives the distribution shown in Table 2.

Table 2: Distribution of Sample by Tillage System.

	Number of Observations
Conventional Till	35
Chisel Plow	31
Minimum Till	29
No Till	61
	156 Total

The farmers chosen for the study were selected from counties in the western Lake Erie Basin where reduced tillage systems promise the greatest chance of economic success. Counties throughout the basin were ranked on their suitability for success with reduced tillage technologies (Forster, July 1979). Of the top 15 counties in this ranking, nine were chosen for inclusion in this study. One other county was also included. The selected counties were Lenawee County, Michigan, Dekalb County, Indiana and Williams, Seneca, Wyandot, Crawford, Allen, Auglaize, Fulton and Mercer Counties, Ohio.

Thus the observations represent a ten county area of the Western Lake Erie Basin. Figure 1 shows the number of observations originating from each county while Figure 2 shows the number of farmers interviewed in each county. As shown in the figures, a total of 89 different farmers provided the 156 total observations.

Observations from the ten counties can be divided into three main groups based on geographical proximity. These geographical areas

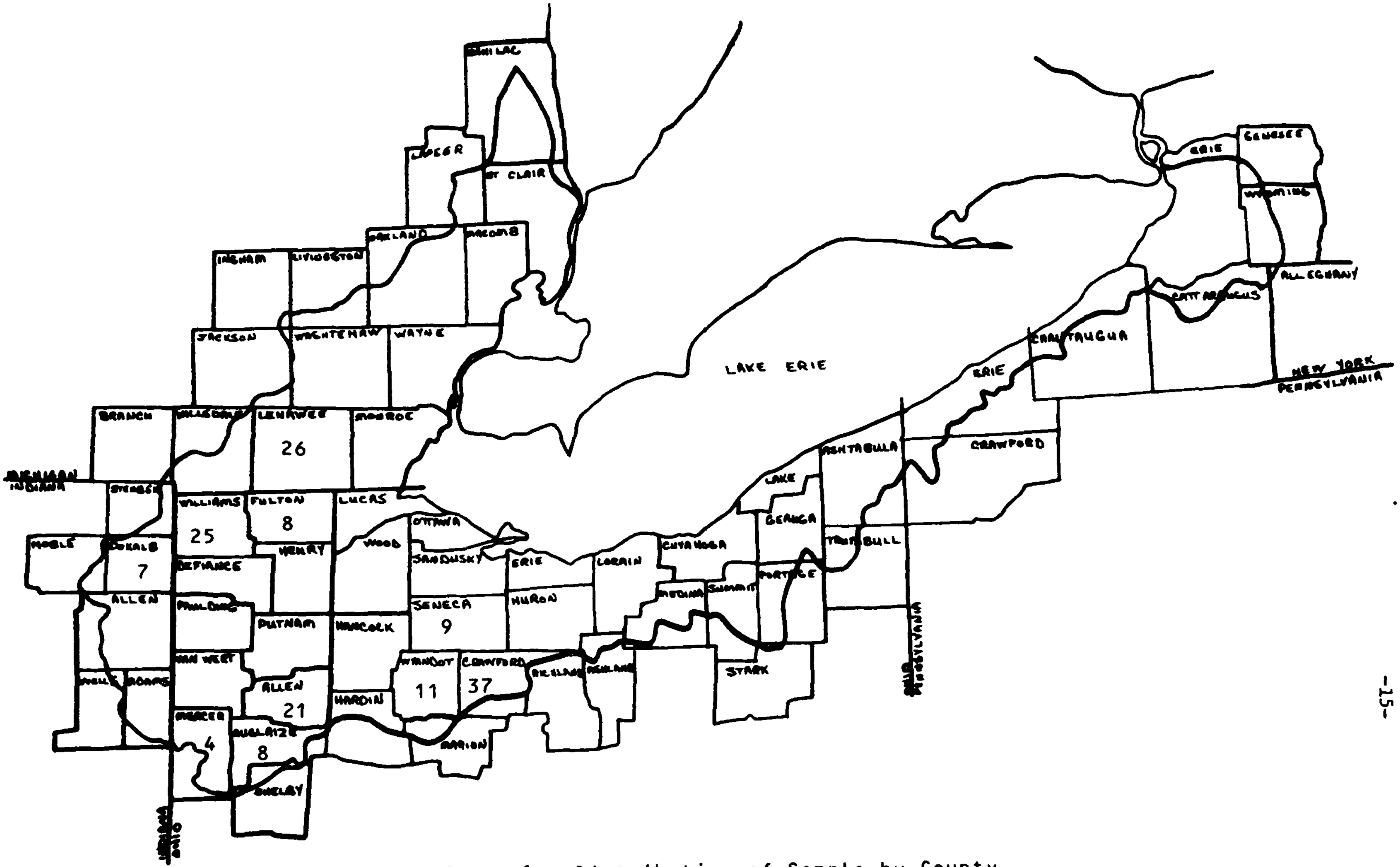

Figure 1: Distribution of Sample by County

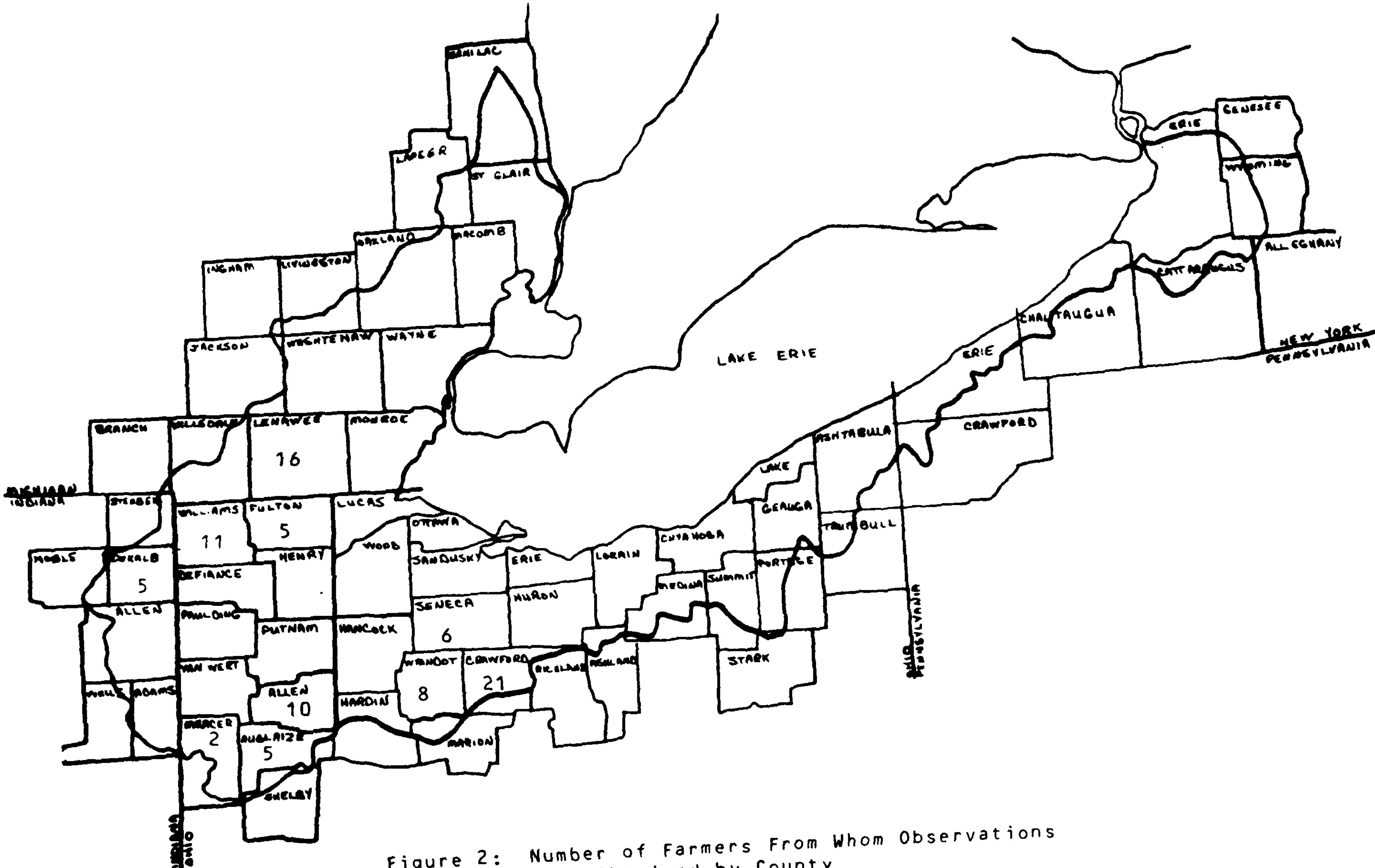

Figure 2: Number of Farmers From Whom Observations Were Obtained by County

include northwestern Ohio, northeastern Indiana and southeastern Michigan (Williams Co., Ohio, Lenawee Co., Michigan, Dekalb Co., Indiana, and Fulton Co., Onio), west-central Ohio (Mercer, Allen and Auglaize counties), and north-central Ohio (Wyandot, Seneca and Crawford counties). The resulting distribution of observations by county group is shown in Table 3. It is thought that counties in each group would share similar climatological conditions as well as similar agricultural characteristics. Also, the three county groups provide a representative picture of agriculture in the western Lake Erie Basin.

Table 3: Distribution of Sample by Tillage System and by County Group.

	County Group		
Tillage System	1[a]	2[b]	3[c]
Conventional Tillage	18	9	8
Chisel Plow Tillage	17	10	4
Minimum Tillage	8	11	10
No Tillage	23	27	11
	66	57	33

[a] Lenawee, Mi.; Dekalb, In.; Williams and Fulton, Oh.

[b] Seneca, Wyandot, and Crawford, Ohio.

[c] Mercer, Auglaize and Allen, Ohio.

Selection of the Sample

After the initial selection of counties to be investigated in the analysis, letters explaining the purposes of the study were sent to Soil Conservation Service personnel in the selected counties. Agents were

asked to supply a list of all farm operators in their counties who were known to be using some form of reduced tillage technology during crop year 1979. Using this list, telephone interviews were conducted to determine the variable costs and yields encountered by basin farmers using alternative tillage practices. Because these reduced tillage technologies and especially no till are rarely used exclusively by farmers, the collection of conventional tillage observations was not difficult.

Several cautions are in order due to this sampling procedure. First, the number of farmers identified as using reduced tillage systems is quite small relative to the total number of county farmers as a whole. While several SCS county offices provided lists of over 30 names, other SCS county offices could provide the names of only three to five operators known to have used reduced tillage during 1979.

Second, the statistical randomness is reduced due to the necessary reliance on SCS county offices. Many interviewees were SCS cooperators or had worked closely with SCS and Cooperative Extension personnel when developing their reduced tillage program. Consequently, the representativeness of this sample is somewhat suspect.

Third, a large number of farmers in the sample have used reduced tillage technologies three or less years compared to the many years of experience with conventional tillage. Thus, results may be biased against some systems such as no till which is considered to require high production skills.

On most of the farms where samples were obtained, more than one tillage system was being used. Often various systems were tried because

of the farmers' interest in comparing for themselves the results of several systems on their farm. In some cases, the soil types on one farm varied to such a considerable degree that the use of different systems was necessary. This was true where heavy clays in low portions of a particular farm gave way to porous sands on the beach ridges of the old Lake Erie Basin.

The use of multiple observations from one farm operation has advantages in that it removes some of the differences due to many unidentified factors. For example, management practices such as planting population, seed variety, harvesting technology and time of harvest may strongly affect the results of a comparison of tillage practices. These factors, however, tend to be constant among the multiple tillage systems used on a particular farming operation.

One factor, however, timeliness of operation is not considered in this analysis despite the fact that reduced tillage offers important advantages for earlier planting given adequate soil temperatures. Agronomists at The Ohio State University estimate that there is a one bushel reduction in yield for every day planting is delayed after May 10. In this study several farmers reported that their no till corn was not planted until the middle of June. This undoubtedly affected adversely the yields for these no till observations.

Another warning is appropriate when interpreting the results of this analysis. There is a great deal of inaccuracy in stating that a particular sample observation was obtained from a plot of land consisting of only one soil series. Fields, even small ones, vary greatly in soil type and may contain as many as 10 nameable soil series within

their perimeters. Therefore when assigning a soil series name to a particular observation, the first criteria for selection was the response of the farmer. When the farmer did not know the predominant soil series, as was often the case, the SCS county agent was contacted for his evaluation of the soil series from which the observation was taken.

Determination of Monetary Values

Because a farmers' investment in field equipment is difficult to obtain and compare with investment data from other farmers, standard rates are adopted. These standard rates for tillage operations are those used in the Honey Creek Watershed Report Tillage Demonstration Results for 1979 and typify the average custom rates in the Lake Erie Basin area. These standard rates include cash operating costs (fuel, oil, repairs, and maintenance) as well as labor costs and fixed costs (depreciation, interest and insurance). The standard rates used for this analysis are shown in Appendix I. Combining the type and number of field operations with the standard rates for field operations allows the costs of field operations to be calculated.

In order to calculate the cost of the fertilizer input, the amount and analysis of each fertilizer applied was obtained for all observations. A basic list of prices per ton was taken from the Honey Creek Watershed Report. The prices of custom blends were estimated using the prices of the known analyses as a guide. The prices of the fertilizers utilized by participating farmers are shown in Appendix II.

Quantities of pesticides used were obtained for each observation. Then pesticide costs are calculated by using price information from the

Honey Creek Watershed Project Report and supplemented with prices obtained from Growers Services of Columbus, Ohio, and Landmark, Inc. of Hilliard, Ohio. Prices of the pesticides used by farmers in the study are shown in Appendix III.

Drying costs are calculated by charging $.02 per bushel per point of moisture dried to 15.5 percent moisture.

Interest on operating capital is determined by taking the sum of the variable input costs (seed, fertilizer, herbicide and insecticide) at 10 percent interest over a seven month growing season.

Results of the Analysis

Costs and Returns

All costs, except tillage, herbicide and fertilizer costs are quite similar between the four tillage systems compared in this study. As mentioned previously, machinery custom rates are used in this analysis to determine tillage costs. Tillage costs are reduced about 23 percent where conventional tillage is replaced by chisel plowing and 43 percent when replaced by minimum tillage (Table 4). On the other hand, herbicide costs are substantially higher with the adoption of no tillage. Herbicides cost almost twice as much for no tillage as they do for the other three tillage systems (Table 4). Fertilizer costs vary somewhat more than would be expected ranging from $52.90 for chisel plow tillage to $64.42 for minimum tillage.

Labor costs are included in machinery custom rates, and no separate labor costs are computed. Survey respondents did provide an estimate of

the total field hours for each tillage system. Field hours average 1.26 hours per acre for conventional tillage. For chisel tillage they are 1.17 hours per acre, for minimum tillage 1.16 hours per acre, and for no tillage 0.88 hours per acre.

Table 4: Tillage, Herbicide and Fertilizer Costs by Tillage System, Sample Farms.

	Costs		
	Tillage	Herbicide	Fertilizer
		--$/acre--	
Conventional	19.13	14.17	55.58
Chisel Plow	14.79	14.41	52.69
Minimum Till	11.00	14.38	64.42
No Till	.00	25.08	59.82

When total variable costs are computed for each tillage system, however, there are no statistically significant differences between the hour tillage systems (Table 5). The total difference in cost is only $7.11 per acre. If significant differences in net returns between tillage systems exist, they are likely to be caused by differences in yields.

Table 5: Sum of Variable Costs by Tillage System, Sample Farms.

	Total Variable Costs [a]
	($/acre)
Conventional Till	172.12
Chisel Plow Tillage	165.01
Minimum Tillage	171.69
No Tillage	169.12

[a] Land costs are excluded.

The net returns from any tillage system stated simply is:

Net Returns = (Yield x Price Received) - Total Variable Costs

In computing net returns for each observation, land costs are excluded. Because the average price of grain received in Ohio is used to represent the price received by all farmers, price received is the same for all observations (Shaudys). Since corn prices are constant and are essentially the same regardless of tillage system, variation in net returns between tillage systems is the result of variation in yields.

Impact of Soils on Yields and Net Returns

Though it may at first be tempting to compare yields and net returns by the four tillage systems, it is in practice not useful. When the total number of tillage observations are classified by tillage only, the four subsets consist of a mixture of observations from all three soil management groups considered in this study.

Each of the three soil management groups consists of soil series with wide ranges in natural fertility and response to agricultural inputs. The Buffalo District of the Corps of Engineers has collected expected yield data for each soil series in the Lake Erie Basin which represent the average yield that can be obtained from a variety of crops incl ding corn. Using this data source, each tillage observation was coded for expected corn yield.

Table 6 shows the average expected yields for each of the soil management groups considered in this study. As easily seen, the expected yield potential of any tillage system could be weighted

unfairly if one of the four tillage systems contained higher percentages of observations from the higher yielding soil management groups.

Table 6: Mean Expected Yield by Soil Management Group for Sample Farms' Soils.

Soil Management Group	Mean Expected Yield
	(bushels/acre)
1	90.9
2	100.5
4	113.2
All Observations	100.3

A more realistic division would be to classify yield and net returns by tillage system and by soil management group. A separate comparison of tillage systems on each soil management group allows testing the hypothesis that the crop's response to alternative tillage systems varies by soil management group. Also, estimates by Forster (Aug. 1978) of different net income changes for each soil management group with the adoption of reduced tillage can be tested.

The distribution of observations by soil management group and by tillage system is shown in Table 7. Unfortunately, the low number of observations for soil management groups 1 and 4, however, may cause low levels of significance when conducting a statistical analysis. Only soil management group 2 contains an adequate number of observations for a separate statistical analysis.

Table 7: Observations by Soil Management Group and by Tillage System, Sample Farms.

Tillage System	Soil Management Group I	II	IV
Conventional Tillage	3	30	2
Chisel Plow Tillage	7	20	4
Minimum Tillage	5	20	4
No Tillage	13	39	9
	28	109	19

In addition to expected yield differences between soil management groups, the observations making up each "soil management group-tillage system" category are made on many different soil series. Thus, each "soil management group-tillage system" category consists of soils with differing yield potentials even though they belong to the same soil management group. To ignore these differences would bias that "soil management group-tillage system" with a mean expected yield above or below the mean expected yield for the soil management group as a whole. Table 8 shows the expected yields by soil management group and by tillage system.

Table 8: Mean Expected Yield by Soil Management Group and by Tillage System.

Tillage System	Soil Management Group I	II	IV
		(bushels/acre)	
Conventional Tillage	81.0	101.6	117.0
Chisel Plow Tillage	87.6	101.0	113.8
Minimum Tillage	97.8	98.9	113.5
No Tillage	92.4	100.2	111.9

The differences in mean expected yield within the same soil management group shows up dramatically within soil management group 1. The mean expected yield for the conventional tillage observations is 81.0 bushels while the mean expected yield for the minimum tillage observations is 97.8 bushels. The variation in net returns and yields caused by the differences in the yield potential of soils must be included in the analysis.

To summarize, there are inherent yield potential differences between each of the soil management groups. In addition, there are differences in the expected yield within each of the soil management groups. To attempt to compare the impact of tillage systems without accounting for these differences would be simplistic if not entirely incorrect. In order to obtain net return figures unbiased by the inherent yield potential of the soil, a regression model was developed to remove variation caused by the differences in soil management group and expected yield.

Regression Analysis

Regression analysis is used to test the hypothesis that net returns from various reduced tillage technologies are not significantly different than those of conventional tillage. The general model also attempts to remove variation due to differences in expected yield as well as detect significant differences in the net returns under the four tillage systems. The model used to test the hypothesis is the following:

$$(1) \qquad Y_i = a_o + \sum_{i=1}^{4} a_i X_i + e$$

where Y_i = net returns per acre

a_i = regression coefficients

X_1 = dummy variable (1 if chisel plow tillage used and 0 if conventional, minimum or no tillage used)

X_2 = dummy variable (1 if minimum tillage used and 0 if conventional, chisel plow or no tillage used)

X_3 = dummy variable (1 if no tillage used and 0 if conventional, chisel plow or minimum tillage used)

X_4 = expected yield per acre

e = error term, normally distributed with a mean of zero.

Net returns per acre are hypothesized to be a function of the tillage system used and the expected yield. Equation (1) does not group the data by soil management group. Separate regression models are run for each soil management group and will be presented later in the analysis.

The results of the estimate for equation (1) show a $20.19 increase in net returns per acre with the adoption of minimum tillage (Table 9). This estimate is significant at the 10 percent confidence level. While the regression coefficients do show an increase in net returns per acre with the adoption of chisel plow tillage and no tillage, the differences cannot be demonstrated to be statistically significant.

A similar regression model is used to determine whether the actual yields under alternative tillage technologies are significantly different than those of conventional tillage. Again, the inclusion of the

Table 9: Regression Results for Net Return Model (1), Using Observations from All Soil Management Groups.

Dependent Variable = Net Returns			
Independent Variables		Equation (1)	
Variable	Description	Estimate	Standard Error
X_0	intercept	2.0	40.37
X_1	Chisel Plow Till (dummy)	7.72	11.59
X_2	Minimum Till (dummy)	20.19 a/	11.79
X_3	No Tillage (dummy)	3.91	9.96
X_4	Expected Yield	1.53 b/	.39
R^2		.11	

a/ Statistically significant at the .10 level.

b/ Statistically significant at the .01 level.

expected yield variable removes variation caused by the differing yield expectation of different soil series. Equation (2) is stated:

$$(2) \quad Y_2 = a_0 + \sum_{i=1}^{4} a_i X_i + e$$

The model uses actual yield per acre as the dependent variable (Y_2) and uses the same independent variables as the model shown in equation (1). The results show a 7.4 bushel increase over conventional tillage with the adoption of minimum tillage (Table 10). The result, however, is only significant at a confidence level of 12 percent. There are no significant statistical differences in the actual yields of conventional, chisel plow and no tillage.

Table 10: Regression Results for Yield Model (2), Using Observations from All Soil Management Groups.

Dependent Variable = Actual Yield

Independent Variables		Equation (2)	
Variable	Description	Estimate	Standard Error
X_0	intercept	52.6	15.94
X_1	Chisel Plow Till (dummy)	.41	4.58
X_2	Minimum Till (dummy)	7.36 a/	4.66
X_3	No Tillage (dummy)	.67	3.93
X_4	Expected Yield	.68 b/	.16
R^2		.13	

a/ Statistically significant at the .12 level.

b/ Statistically significant at the .01 level.

Separate regression models are used on each of the three major soil management groups to test the hypotheses that returns and yields from reduce tillage systems are statistically different than those of conventional tillage. The same independent variables were used in these models as were used in the general models (Equations 1 and 2).

The first two models analyze those observations on soil management group 1. The independent variables Y_1 and Y_2 are again net returns per acre and yield per acre. The results of this model (Tables 11 and 12) show an increase in net returns and yields (except chisel plow tillage) with the adoption of reduced tillage technology, but these results are not statistically significant. The low number of samples on this soil

management group (28) exacerbates the problem of statistically analyzing the impacts of reduced tillage.

The next set of regression models analyze the results of observations on soil management group 2 soils. The results of the regression analysis on observations obtained on soil management group 2 soils (Tables 13 and 14) show increased net returns as well as increased yield with the adoption of reduced tillage. Only minimum tillage, however, shows increases in net returns significant at a 20 percent level of

Table 11: Regression Results for Net Return Model, Using Observations from Soil Management Group 1.

Dependent Variable = Net Returns			
Independent Variables		Equation	
Variable	Description	Estimate	Standard Error
X_0	Intercept	83.24	63.28
X_1	Chisel Plow Till (dummy)	10.90	28.40
X_2	Minimum Tillage (dummy)	25.78	32.04
X_3	No Tillage (dummy)	15.08	27.27
X_4	Expected Yield	.39	.73
R^2		.07	

Table 12: Regression Results for Yield Model, Using Observations from Soil Management Group 1.

Dependent Variable = Actual Yield

Independent Variables		Equation	
Variable	Description	Estimate	Standard Error
X_0	intercept	73.2	28.73
X_1	Chisel Plow (dummy)	-.21	2.89
X_2	Minimum Tillage (dummy)	7.4	14.55
X_3	No Tillage (dummy)	.60	12.38
X_4	Expected Yield	.37	.33
R^2		.11	

Table 13: Regression Results for Net Return Model, Using Observations from Soil Management Group 2.

Dependent Variable = Net Returns

Independent Variables		Equation	
Variable	Description	Estimate	Standard Error
X_0	intercept	7.93	86.3
X_1	Chisel Plow Till (dummy)	8.43	16.15
X_2	Minimum Tillage (dummy)	21.54 a/	16.30
X_3	No Tillage (dummy)	6.47	13.40
X_4	Expected Yield	.84	.85
R^2		.03	

a/ Statistically significant at the .20 level.

Table 14: Regression Results for Yield Model, Using Observations from Soil Management Group 2.

Dependent Variable = Actual Yield

Independent Variables		Equation	
Variable	Description	Estimate	Standard Error
X_0	intercept	87.08	29.52
X_1	Chisel Plow Till (dummy)	.92	5.49
X_2	Minimum Tillage (dummy)	7.89 [a]	5.54
X_3	No Tillage (dummy)	1.64	4.63
X_4	Expected Yield	.35	.29
R^2		.03	

[a] Statistically significant at the .16 level.

confidence. Yield increases above those of conventional tillage are significant at only a 16 percent level of confidence.

Finally models are used to analyze observations on soil management group 4 soils (Tables 15 and 16). Results show net returns to be more than $28.00 higher with minimum tillage than with conventional tillage. Chisel plowing improves net returns $19.00 per acre. Only no tillage results in net returns lower than those of conventional tillage. Partially because of the small number of observations, the standard error for each of these estimates is extremely high, and none of the findings can be considered statistically significant. Similarly, a ten bushel per acre increase could be obtained with the adoption of minimum tillage. Chisel plowing improves yields by 7 bushels per acre. Even no

tillage shows a 3.9 bushel advantage over conventional tillage. As with net returns, however, these results cannot be considered statistically significant.

Generally, for each soil management group, yields and net returns are not significantly different between tillage systems. Obviously, the analyses fail to demonstrate that there are systematic differences in net returns and yields for most farms in the sample. The correlation coefficient for each model is relatively low (.03 to .19), thus there

Table 15: Regression Results for Net Return Model, Using Observations from Soil Management Group 4.

Dependent Variable = Net Returns			
Independent Variables		**Equation**	
Variables	Description	Estimate	Standard Error
X_0	intercept	7.70	237.93
X_1	Chisel Plow Till (dummy)	18.85	36.82
X_2	Minimum Tillage (dummy)	28.76	36.82
X_3	No Tillage (dummy)	-4.13	34.89
X_4	Expected Yield	1.61	2.02
R^2		.19	

Table 16: Regression Results for Yield Model, Using Observations from Soil Management Group 4.

Dependent Variable = Actual Yield			
Independent Variables		Equation	
Variables	Description	Estimate	Standard Error
X_0	Intercept	81.69	88.45
X_1	Chisel Plow Till (dummy)	7.27	13.94
X_2	Minimum Tillage (dummy)	10.27	13.97
X_3	No Tillage (dummy)	3.90	12.97
X_4	Expected Yield	.42	.75
R^2		.07	

are large variations in net returns and yields caused by factors other than tillage practices. Rainfall, planting and harvesting dates, row spacing, drainage systems, equipment performance and a multitude of other factors account for this large variation unexplained by tillage practices.

However, regression coefficients (the a_i's in each regression equation) provide estimates of the average impact of alternative tillage systems. They can be used to provide an indication of the anticipated changes in net returns and yields should reduced tillage systems be adopted on selected soils within the western Lake Erie Basin.

With these regression coefficient estimates, net returns and yields are projected for alternative tillage and soil management group settings (Table 17 and 18). Mean expected yields for each soil management group

(Table 6) are used with the regression equations shown in Tables 9 through 16. Using this procedure removes the effect of differences in inherent soil productivity within a soil management group. That is, only tillage systems affect the yields and net returns within a soil management group. As shown in Table 17, minimum tillage is projected to be the most profitable tillage method for each of the three soil management groups considered. Net returns for each of the reduced tillage practices for soil management groups 1 and 2 are in fact higher than the net returns for conventional tillage for those same soil groups. Only in soil management group 4 are the net returns for conventional tillage greater than those of no tillage.

Table 18 shows yields as projected by the regression coefficient estimates. On soil management groups 1 and 2, only minimum tillage shows projected yields that differ significantly from the other three tillage systems. On soil management group 4, projected yields for all three alternative tillage systems are larger than the projected yields for conventional tillage. When all observations are grouped together, yields under minimum tillage are projected to be higher than yields under the other tillage systems examined in this study. Yields projected under chisel plow tillage and no tillage are slightly higher than conventional tillage. However, no statistical significance can be attached to these estimates.

Projected Changes in Net Returns

Net return indices are computed for each soil management group-tillage system combination. For each soil management group, net returns

are indexed on the basis of conventional tillage, net returns equalling 100 (Table 19). For example, the net return index for chisel plow tillage is 109.2 or 9.2 percent higher than the net returns of conventional tillage on soil management group 1. The net return index is 121.7 for minimum tillage on the same soil management group soils.

Table 17: Projected Net Returns by Soil Management Group and by Tillage System

Tillage System	Soil Management Group I	II	IV	All Obs.
	--$/acre--			
Conventional Tillage	118.70	156.33	188.82	155.46
Chisel Plow Tillage	129.60	164.76	207.67	163.18
Minimum Tillage	144.48	177.87	217.58	175.65
No Tillage	133.78	162.80	184.69	159.37

Table 18: Projected Yields by Soil Management Group and by Tillage System

Tillage System	Soil Management Group I	II	IV	All Obs.
	--bushels/acre--			
Conventional Till	106.8	122.3	129.2	120.8
Chisel Plow Till	106.6	123.2	136.5	121.2
Minimum Tillage	114.3	130.2	139.3	128.2
No Tillage	107.4	123.9	133.1	121.5

These indices may be considered the change in net returns over the ten county sample area should corn by planted on 100 percent of the available cropland.

Table 19: Projected Net Return Indices by Soil Management Group and by Tillage System.

Tillage System	Soil Management Group I	II	IV	All Obs.
Conventional Till	100	100	100	100
Chisel Plow	109.2	105.4	110.0	105.0
Minimum Till	121.7	113.8	115.2	113.0
No Tillage	112.7	104.1	97.8	102.5

The same procedure may be followed to compute actual yield indices for each soil management group-tillage system combination (Table 20). For example, the yield index for chisel plow tillage shows the yield to be 0.2 percent less than the yield under conventional tillage on soil management group 1. The yield index is 107.0 for minimum tillage on the same soil management group soils.

Table 20: Projected Yield Indices by Soil Management Group and by Tillage System.

Tillage System	Soil Management Group I	II	IV	All Obs.
Conventional Till	100	100	100	100
Chisel Plow Till	99.8	100.6	104.5	100.3
Minimum Tillage	107.0	106.4	106.6	106.1
No Tillage	104.6	100.9	101.3	100.6

These indices if applied to soil management groups in the ten county sample can be used to predict cnanges in net returns and actual yields with the adoption of reduced technologies (Tables 21 and 22).

Forster projected changes in net returns for all Lake Erie Basin counties with the adoption of reduced tillage systems (Forster, Aug. 1978). His estimated changes in net returns for corn in the 10 county sample area are shown in parenthesis in Table 21.

Results of the survey data for soil management group 1 show a positive change in net returns but generally lower than that predicted by Forster. The actual net returns change is +9.2 percent, +21.7 percent and +12.7 percent for chisel plow tillage, minimum tillage, and no tillage respectively.

On soil management group 2 soils, the net returns were somewhat more variable. The percentage change in net returns is +5.4 percent

Table 21: Change in Net Returns for Corn Grown in 10 Selected Counties in the Western Lake Erie Basin Under Alternative Tillage Practices by Soil Management Group. [a]

Tillage System	Soil Management Group I	II	IV
		--%--	
Conventional Till	-	-	-
Chisel Plow Till	+ 9.2 (+12.6)	+ 5.4 (+25.2)	+10.0 (- 3.4)
Minimum Tillage	+21.7 (+12.6)	+13.8 (+25.2)	+15.2 (- 3.4)
No Tillage	+12.7 (+25.2)	+ 4.1 (+28.7)	- 2.2 (-21.9)

[a] Figures in parentheses are those predicted by Forster's model as used in "Economic Impacts of Changing Tillage Practices in the Lake Erie Basin", August, 1978.

Table 22: Change in Actual Yield for Corn Grown in 10 Selected Counties in the Western Lake Erie Basin with the Usage of Alternative Tillage Practices by Soil Management Group. [a/]

Tillage System	Soil Management Group I		II		IV	
	--%--					
Conventional Till	-		-		-	
Chisel Plow Till	- 0.2	(0.0)	+0.6	(+5.00)	+4.5	(- 4.00)
Minimum Till	+ 7.0	(0.0)	+6.4	(+5.00)	+6.6	(- 4.00)
No Tillage	+ 0.6	(2.0)	+0.9	(+4.00)	+1.3	(-13.00)

a/ Figures in parentheses are those predicted by Forster's model as used in "Economic Impacts of Changing Tillage Practices in the Lake Erie Basin", August, 1978.

for chisel plow tillage, +13.8 percent for minimum tillage and +13.0 percent for no tillage. Though these figures are considerably lower than those predicted by Forster, it is important to note that all alternative tillage systems showed a positive change in net returns for the 10 county area.

The change in net returns for soil management group 4 soils shows a positive response resulting in increased net returns under chisel plow and minimum tillage. Forster's model predicted slight net returns decreases with the adoption of minimum tillage on group 4 soils. Net returns decreased with the use of no tillage on soil management group 4 soils. This is as predicted by Triplett et al. in their original soil management group classification.

Table 22 compares the actual yield indices for each soil management group-tillage system combination (Table 20) with the yield indices obtained from experimental trials in Ohio and data adapted or estimated

by experts in other states (Table 1). This comparison is extremely important since Forster's projection of changes in basin net returns with the adoption of reduced tillage practices is based upon results from research plots. It is important to determine whether these experimental results are realistic projections of what basin farmers can expect with the adoption of reduced tillage on selected soils.

For soil management group 1 soils, experimental indices approximate the actual yield indices. Experimental indices estimate yields under minimum tillage on group one soils to be equal to those of conventional tillage. As shown in Table 22 yields with minimum tillage exceed those of conventional tillage by 7.0 percent. However, actual yield indices and experimental yield indices are nearly the same for chisel plow tillage and no tillage.

For soil management group 2 soils, only yields under minimum tillage exceed the yield increases predicted by experimental yield indices. Yields under both chisel plow tillage and no tillage fall below yields as expected from previous research.

Actual yields on soils from soil management group 4 show positive response with the adoption of reduced tillage. The experimental indices on the other hand predict a negative response to both minimum tillage and no tillage on these soils.

Summary and Conclusions

It is hypothesized that using reduced tillage systems on selected soils has little or no effect on producers' net returns in the Lake Erie Basin. Also, reduced tillage technologies can substantially reduce soil

loss and improve water quality in Lake Erie. The soils which are thought to be best suited for reduced tillage systems are soil series in soil management groups 1 and 2 of the classification identified by Triplett, et al.. Soil management group 4 also is thought to be suitable for reduced tillage.

This study selected 156 observations of corn production where the predominant soil series were from soil management groups 1, 2 and 4. Conventional tillage technologies were used on 35 of the observations, chisel plow tillage on 31 of the observations, minimum tillage on 29 of the observations and no tillage on 61 of the observations. The observations were dispersed across 10 counties of the western Lake Erie Basin. These observations were based on corn production in the 1979 crop year under existing farm management practices of the sample farm operators.

Results of this study seem to indicate that minimum tillage does indeed increase net returns above those obtainable with conventional tillage. Net returns with chisel plow and no tillage may be higher than those of conventional tillage though the results cannot be proven to be statistically significant.

Several factors should be kept in mind when interpreting these results. First, although 156 observations is a relatively large sample size, the low number of observations on soil management groups 1 and 4 does not permit inferences to be made with high levels of statistical significance for these soil management groups. Unfortunately it was not possible to know before an interview on what soil series a farmer had utilized reduced tillage. Perhaps a greater number of tillage observations would

contain enough samples from soil management groups 1 and 4 to permit more conclusive evidence that reduced tillage on these soils are more or less profitable than conventional tillage.

Second, one year's observations about agronomic practices may lead to inconclusive results in the long run about the profitability of reduced tillage on selected soils. Climate may affect one tillage system more than another for a specific year and several years observations may be necessary to sort out these climatic effects.

Third, several farmers in the sample participated in tillage demonstration projects. There is the possibility that results from farmers' participating in tillage demonstration plots may be biased towards reduced tillage. Reduced tillage systems on demonstration plots have the advantage of technical expertise not in existance on most farms. Basin farmers have had long experience with conventional tillage, but are relatively inexperienced with reduced tillage systems. Over time their expertise with reduced tillage systems can be expected to improve.

Phase II Findings and This Study's Results

Nonpoint source pollution is derived principally from agricultural land use, particularly crop production. This finding is one of the major conclusions reached during Phase II of the Lake Erie Wastewater Management Study under the direction of the U.S. Army Corps of Engineers. This result suggests that programs based on reducing the delivery of sediment phosphorus to the lake should be based on erosion reduction programs for agricultural lands. It is estimated in the study

that the reduction in delivered phosphorus resulting from a given decrease in potential gross erosion appears to be between 60 and 90 percent.

The adoption of conservation tillage and no tillage on appropriate soils can potentially reduce gross erosion in the basin by 47 to 69 percent. In addition, reduced tillage technologies on these appropriate soils are considered to be economically feasible in the Lake Erie Basin which contains what are generally considered to be soils responsive to these practices. Forster (Aug. 1978) suggests increased basin net income with the adoption of reduced tillage on soil series appropriate for those practices.

It is believed that farmers will be quicker to respond to the incentive of increased net returns with the adoption of reduced tillage technologies than with basin-wide attempts to change cover, land use and crop rotations. Consequently the adoption of reduced tillage is thought to have the greatest potential for reducing phosphorus loadings to Lake Erie due to agricultural land use.

This study has attempted to test the hypothesis that the use of alternative tillage on selected soils results in little change in net returns for basin farmers. The results indicate that the use of minimum tillage does result in significantly higher net returns than conventional tillage for these 156 observations on three selected soil management groups. Chisel plow tillage and no tillage may result in higher net returns though for this study the differences cannot be ascertained to be statistically significant.

APPENDIX I

MACHINE CUSTOM RATES

Plow..	$10.00/acre
Chisel w/twisted shanks.....................	7.50
Chisel w/shovels............................	7.50
Field Cultivate.............................	5.50
Tandem Disk.................................	5.00
Flexible Disk...............................	4.00
Cultimulcher................................	4.00
Row Cultivate...............................	4.00
Rotary Hoeing...............................	2.50
Spray Liquid................................	3.00
Spread Fertilizer...........................	3.00
Apply Anhydrous Aonia.......................	5.50
Plant (No Till).............................	10.00
Plant (Conventional)........................	7.00
Harvest.....................................	18.00

APPENDIX II

FERTILIZER PRICES

0-0-61 ....$117 per ton	8-24-4 ....$165 per ton
0-10-30 ...... 134 "	8-24-3 .... 164 "
0-22-30 ...... 150 "	8-25-3 .... 165 "
0-44-0 .... 145 "	8-27-12 .... 156 "
0-13-43 ...... 144 "	8-32-16 .... 166 "
0-15-40 ...... 145 "	8-33-17 .... 168 "
3-9-48 .... 154 "	9-18-9 .... 146 "
3-17-40 ...... 148 "	9-23-30 .... 154 "
4-10-10 ...... 130 "	9-29-19 .... 160 "
5-15-40 ...... 148 "	9-36-18 .... 170 "
5-20-20 ...... 148 "	10-10-10 .... 136 "
5-14-42 ...... 147 "	10-26-26 .... 161 "
6-12-47 ...... 148 "	10-34-0 .... 167 "
6-15-40 ...... 149 "	10-35-10 .... 170 "
6-18-6 .... 142 "	10-20-10 (liq)... 2.60/gal
6-18-36 ...... 150 "	12-30-20 .... 170 per ton
6-24-12 ...... 148 "	15-40-5 .... 190 "
6-24-24 ...... 152 "	18-24-9 .... 155 "
6-26-26 ...... 158 "	18-32-16 .... 166 "
7-18-38 ...... 152 "	18-46-0 .... 200 "
7-22-5 .... 161 "	30-0-20 .... 170 "

APPENDIX III

PESTICIDE PRICES

Atrazine 80W	$ 2.00/lb.
Atrazine 4L	11.00/gal.
Banvel D	33.25/gal.
Bladex 4L	13.00/gal.
Bladex 80W	2.45/lb.
Dual 6E	26.50/gal.
Dual 8E	35.50/gal.
Lasso 4EC	16.00/gal.
Lasso 10G	.60/lb.
Paraquat ICL	40.00/gal.
Roundup	58.00/gal.
Sutan 6.7E	15.00/gal.
Furadan 10G	.75/lb.
Dyfonate 20G	1.00/lb.
Counter	1.05/lb.
Mocap	.60/lb.

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